Electronic Supplementary Material (ESI) for RSC Advances.

Supporting information

Facile synthesis of ternary PtPdCu alloy hexapods as highly efficient electrocatalysts for methanol oxidation

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Table S1 ICP-AES data of the PtCu nanodendrites and PtPdCu hexapods.

Samples	Pt/Pd/Cu atomic ratio	wt% of Pt
Pt_3Cu_7	3:0:7	56.8
Pt_2PdCu_4	2.4:1:4	56.5
Pt_3PdCu_4	3.2:1:4.1	62.8
Pt_5PdCu_5	4.6:1:4.8	68.4

Table S2 Summarized XPS data of Pt_2PdCu_4, Pt_3PdCu_4, Pt_5PdCu_5, bulk Pt, and bulk Cu.

Samples	Pt^0 $4f_{7/2}$	Pt^0 $4f_{5/2}$	Cu^0 $2p_{3/2}$	Cu^0 $2p_{5/2}$
Pt_2PdCu_4	70.66 eV	73.99 eV	932.3 eV	952.1 eV
Pt_3PdCu_4	70.74 eV	74.07 eV	932.1 eV	951.9V
Pt_5PdCu_5	70.81 eV	74.14 eV	932.0 eV	951.8 eV
Pt bulk	71.2 eV	74.53 eV	/	/
Cu bulk	/	/	931.7 eV	951.5 eV

Table S3 ECSA, specific activity and mass activity of PtCu nanodendrites, three PtPdCu hexapods and Pt/C catalysts.

Samples	ECSA(m^2/g_{Pt})	i_s(mA/cm^2)	i_m ($mA/\mu g_{Pt}$)
Pt_3Cu_7	26.4	0.98	0.26
Pt_2PdCu_4	12.2	3.53	0.43
Pt_3PdCu_4	11.1	5.95	0.66
Pt_5PdCu_5	13.2	7.39	0.97
Pt/C	46.7	0.38	0.18

Table S4 Comparison of MOR activities of Pt_5PdCu_5 hexapods in this work with state of art electrocatalysts in the literatures.

Samples	Electrolyte	*i*s (mA/cm^2)	*i*m (mA/μg$_{pt}$)	Ref.
Pt_5PdCu_5	0.5 M H_2SO_4 + 0.5 M CH_3OH	7.39	0.97	This work
np-Pt-Cu	0.5 M H_2SO_4 + 1.0 M CH_3OH	4.9	0.75	1
PtNi CNCs	0.5 M H_2SO_4 + 0.5 M CH_3OH	1.37	0.70	2
PtRu NCs	0.1 M $HClO_4$ + 1.0 M CH_3OH	2.7	1.08	3
np-PtRuCuOsIr	0.5 M H_2SO_4 + 0.5 M CH_3OH	3.0	0.86	4
PtCo/EG	0.5 M H_2SO_4 + 1.0 M CH_3OH	0.94	0.53	5
PtRuFe	0.5 M H_2SO_4 + 1.0 M CH_3OH	2.03	1.14	6
Pd@Pt/GN(PDDA)	0.5 M H_2SO_4 + 1.0 M CH_3OH	0.13	0.87	7
PtCu nanostars	0.5 M H_2SO_4 + 1.0 M CH_3OH	3.45	0.574	8
PtFeCu	0.5 M H_2SO_4 + 0.5 M CH_3OH	1.783	0.622	9
PtPdCu Nanodendrites	0.5 M H_2SO_4 + 0.5 M CH_3OH	0.693	0.52	10
$PtFe_{0.9}Cu_{0.1}$/C-700	0.5 M H_2SO_4 + 1.0 M CH_3OH	3.07	0.707	11
Au@PtCu nanostars	0.1 M $HClO_4$+ 1.0 M CH_3OH	1.06	0.178	12

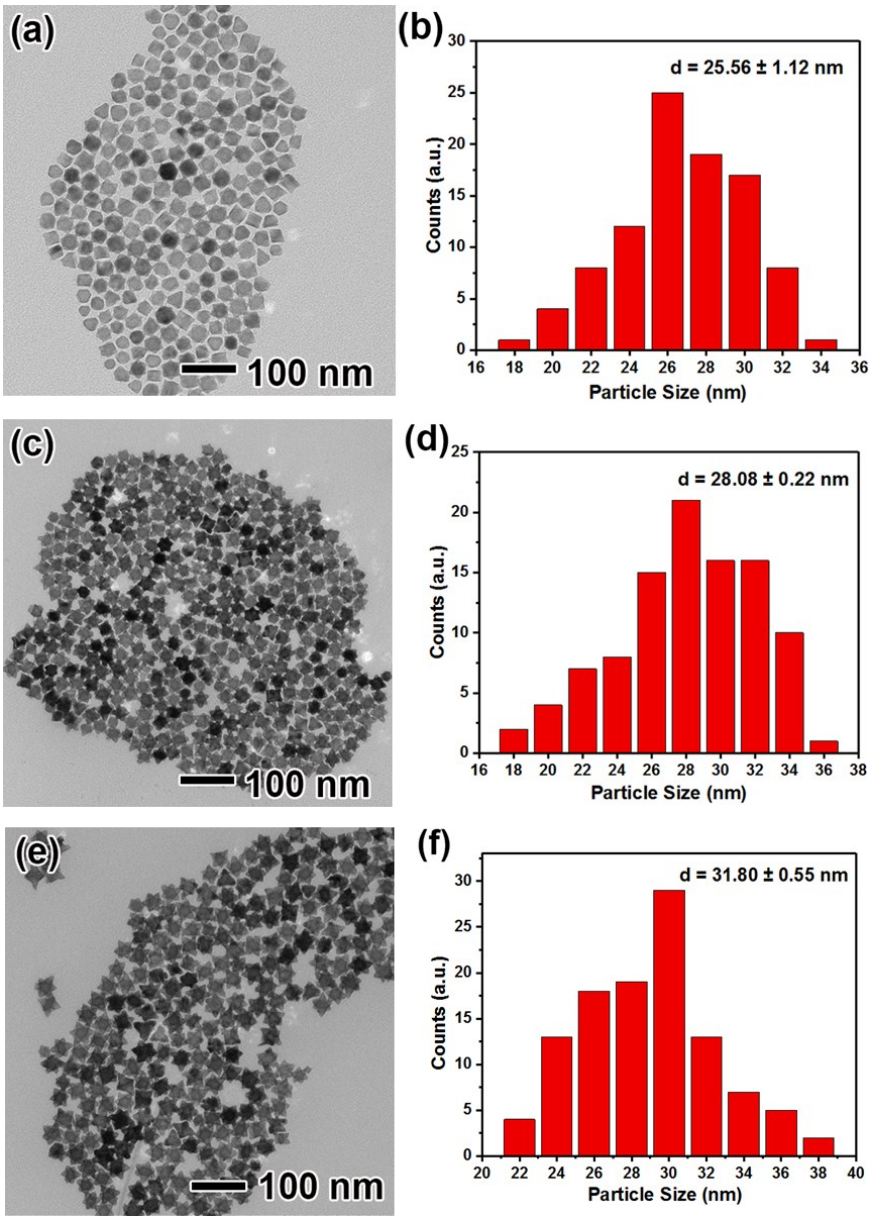

Fig. S1 (a, c, e) TEM images and (b, d, f) corresponding size distributions of the Pt_2PdCu_4, Pt_3PdCu_4 and Pt_5PdCu_5 hexapods.

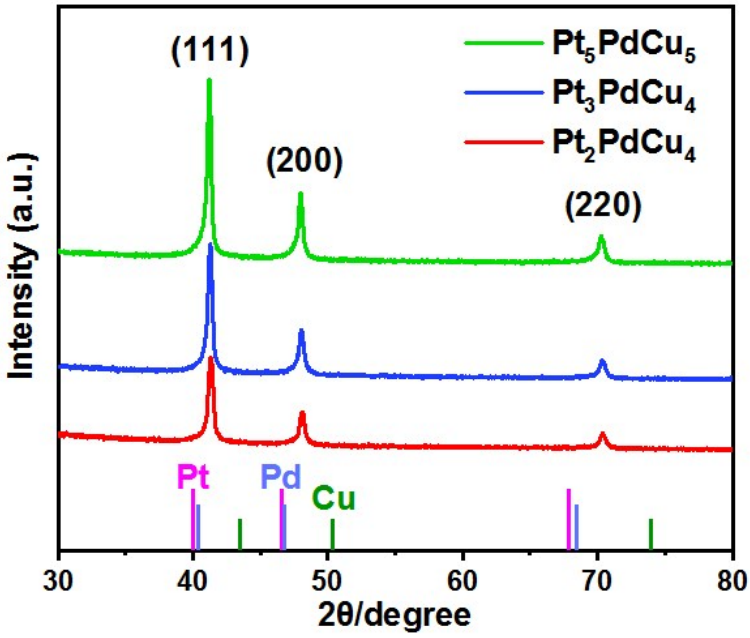

Fig. S2 XRD patterns of the Pt_2PdCu_4, Pt_3PdCu_4 and Pt_5PdCu_5 hexapods.

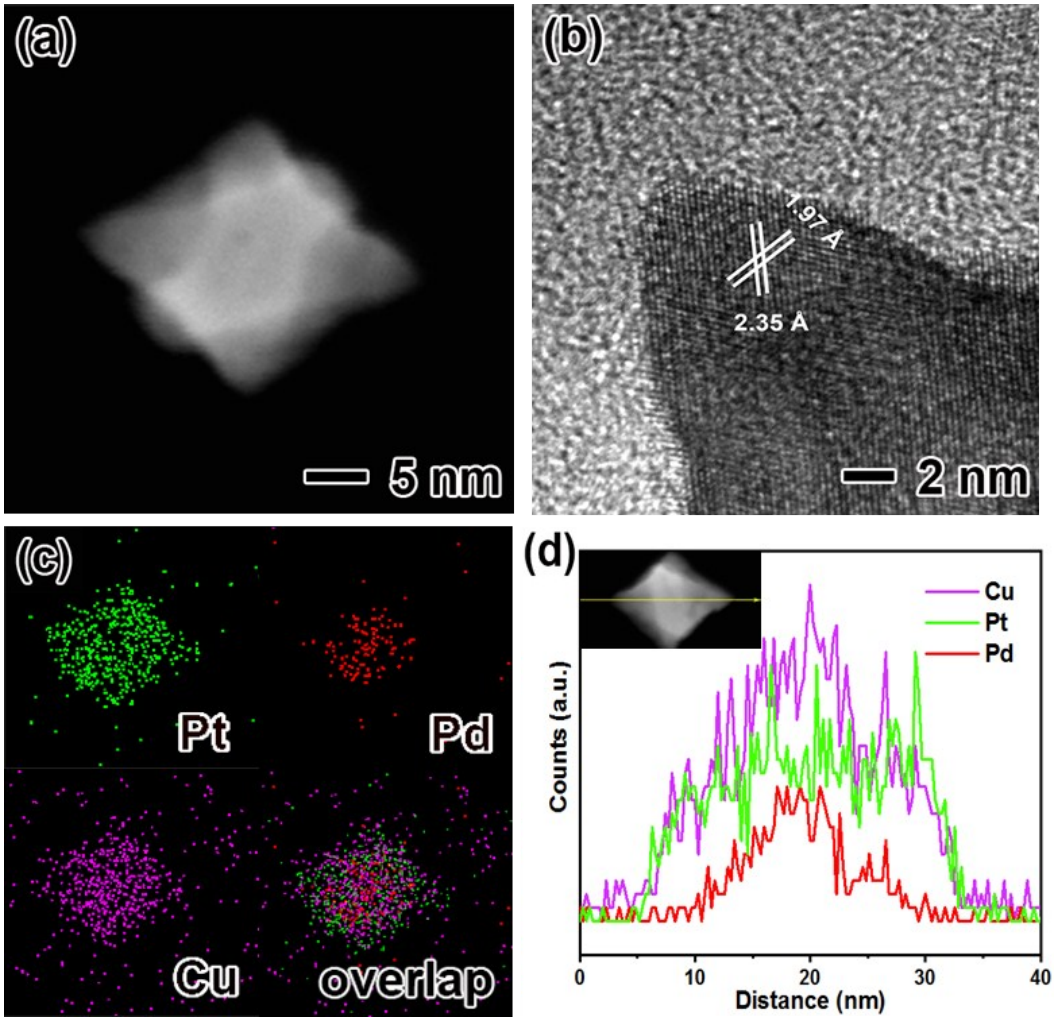

Fig. S3 Morphological, structural, and compositional characterizations of the Pt_3PdCu_4 hexapods: (a) HAADF-STEM image, (b) HRTEM image, (c) EDX mapping image, and (d) line-scan profiles.

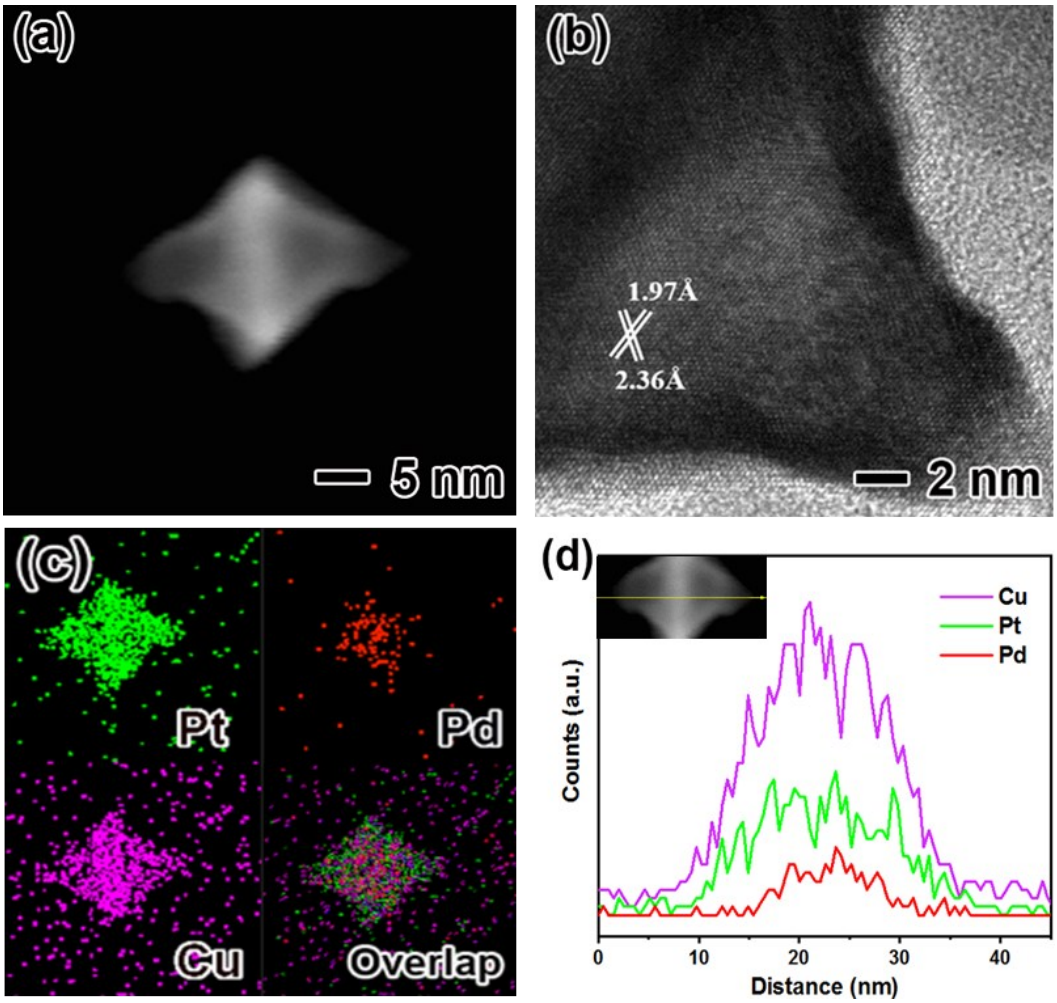

Fig. S4 Morphological, structural, and compositional characterizations of the Pt_2PdCu_4 hexapods: (a) HAADF-STEM image, (b) HRTEM image, (c) EDX mapping image, and (d) line-scan profiles.

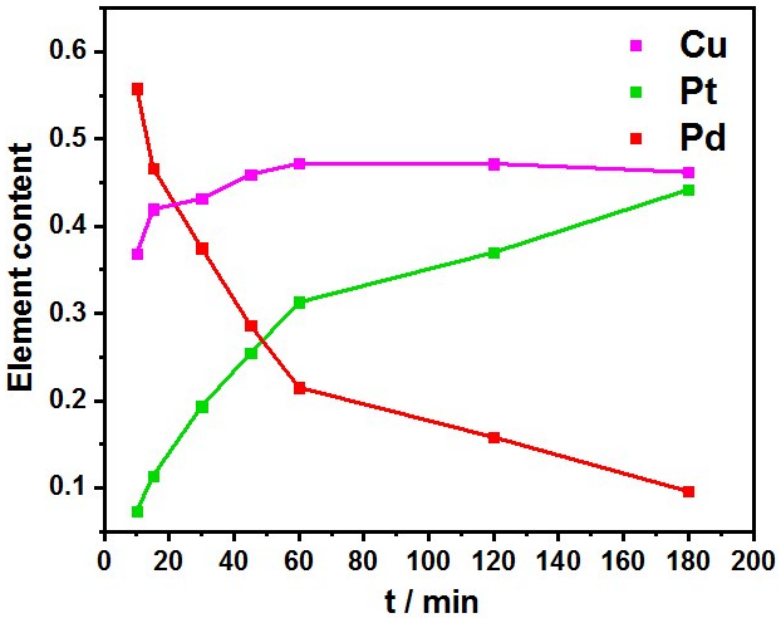

Fig. S5 Change in mol % of Pt, Pd and Cu during the reaction for the synthesis of the Pt_5PdCu_5 hexapods.

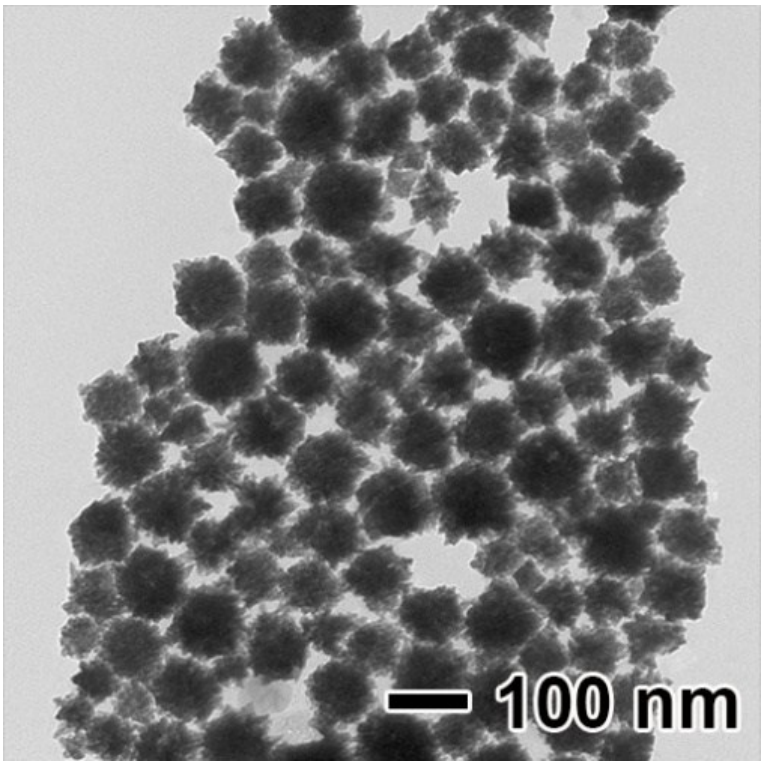

Fig. S6 TEM image of the PtCu nanodendrites prepared using the standard procedure in the absence of $Pd(acac)_2$.

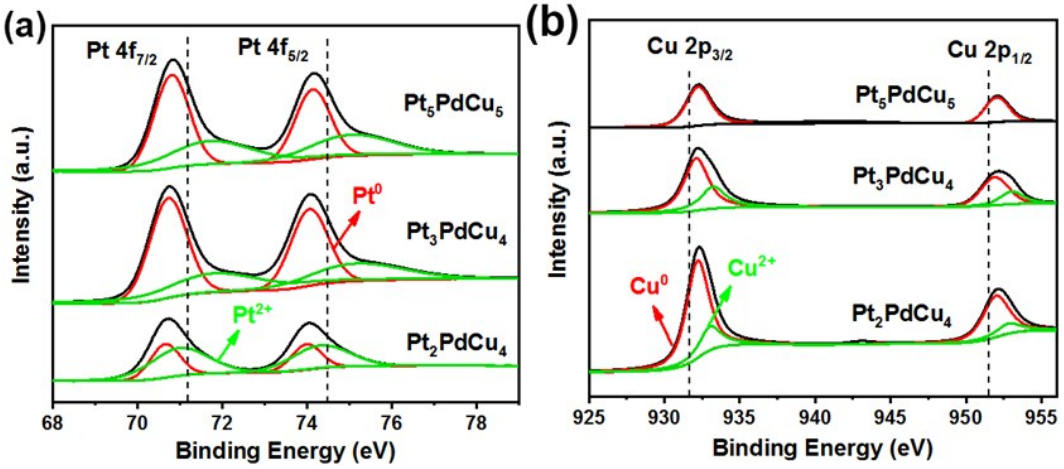

Fig. S7 (a) Pt 4f, (b) Cu 2p XPS spectra of Pt_5PdCu_5, Pt_3PdCu_4, Pt_2PdCu_4 hexapods, respectively.

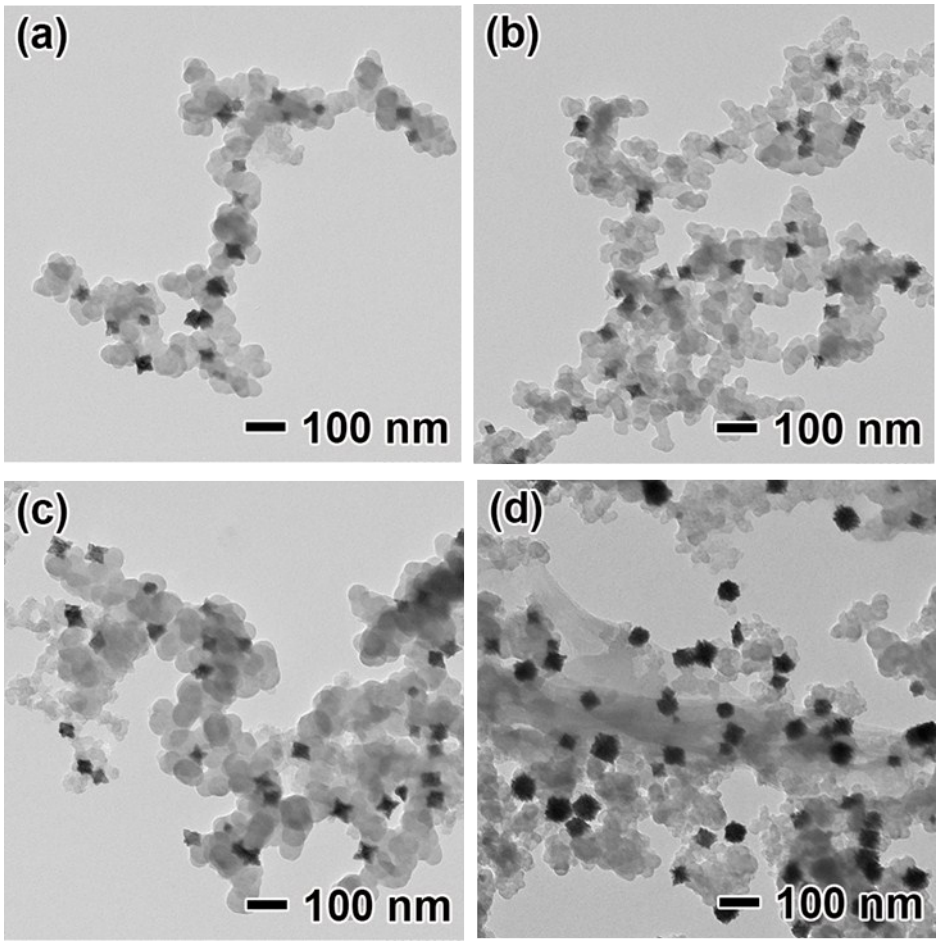

Fig. S8 TEM images of these four nanoparticles that loaded on carbon support: (a) Pt_2PdCu_4 hexapods, (b) Pt_3PdCu_4 hexapods, (c) Pt_5PdCu_5 hexapods and (d) Pt_3Cu_7 nanodendrites.

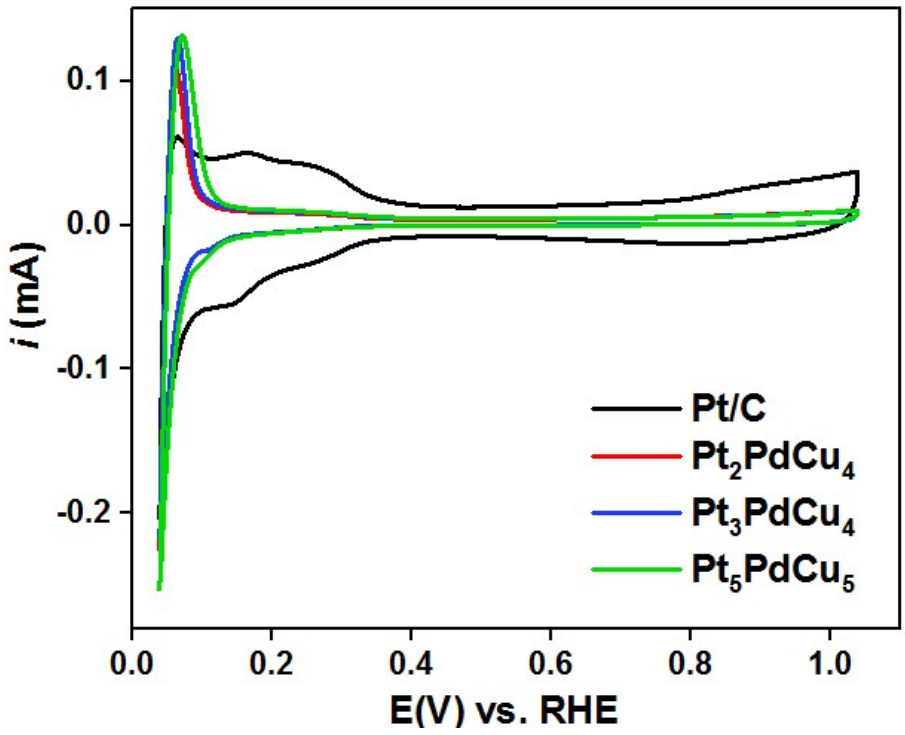

Fig. S9 Cyclic voltammetry (CV) curves of Pt_2PdCu_4, Pt_3PdCu_4, Pt_5PdCu_5 and commercial Pt/C catalysts recorded in Ar-saturated 0.1 M $HClO_4$ solution with a scan rate of 50 mV/s.

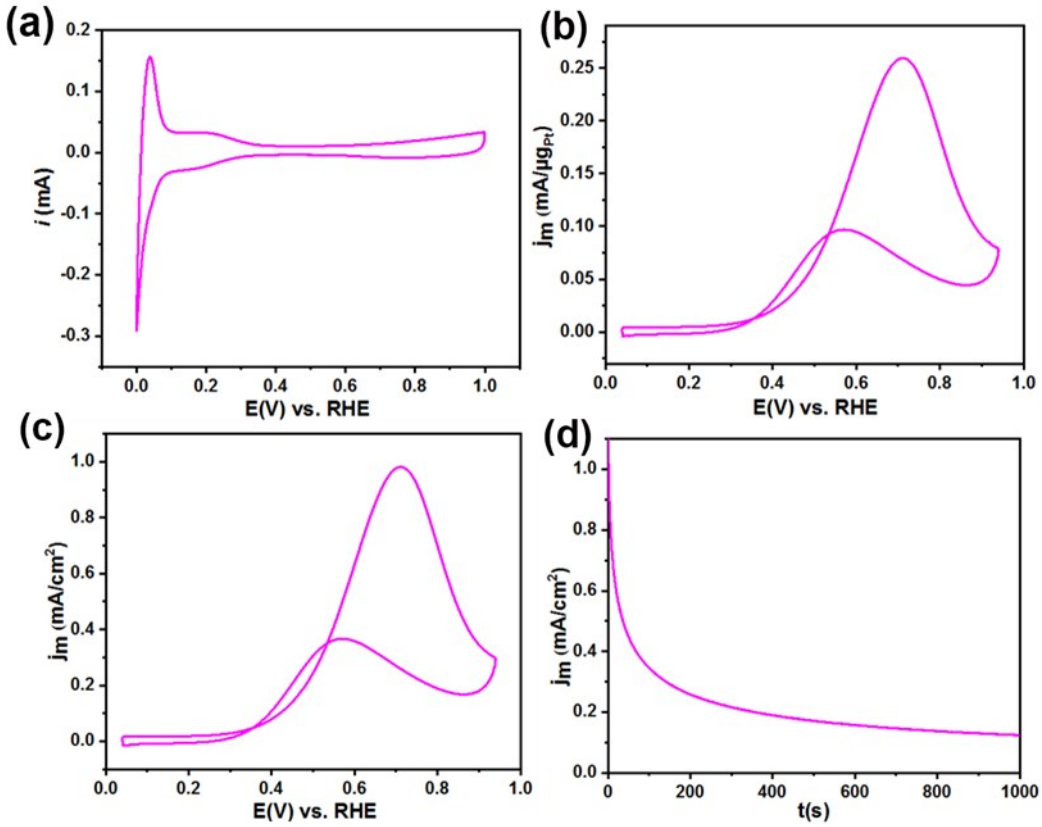

Fig. S10 (a) Cyclic voltammetry (CV) curves of PtCu catalyst recorded in Ar-saturated 0.1 M $HClO_4$ solution with a scan rate of 50 mV/s. (b, c) Cyclic voltammograms (CVs) of PtCu catalyst for the MOR normalized by the ECSA and Pt mass. (d) Current–time curves (I-t) for methanol electrooxidation of PtCu catalyst at the peak position voltage (vs. RHE) for 1000 s.

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